No. 9. — *Contributions from the Petrographical Laboratory of the Harvard University Museum.*

III.

On Keratophyre from Marblehead Neck, Massachusetts.

By John H. Sears.

This interesting rock formation was first noticed by Prof. W. O. Crosby in the American Naturalist (Vol. XI. No. 10, 1877, p. 585), where he says: "Near the middle of the southwest side of the harbor, visible only at low tide, is a hard, whitish, fine-grained sandstone or arenaceous slate. It overlies unconformably the banded petrosilex found on the shore." In the "Occasional Papers of the Boston Society of Natural History, III. Contributions to the Geology of Eastern Massachusetts," Professor Crosby says again of Marblehead Neck (p. 263): "It is not generally known that this rocky peninsula, which may be regarded as lying on the extreme outskirts of the Boston Basin, includes beds probably referable to the same horizon as the slate and conglomerate on the south and west. Briefly stated the facts are as follows: Near the middle of the northwest shore of the Neck, visible only at low tide, is a hard, whitish, fine-grained sandstone or arenaceous slate; it is evidently largely feldspathic and turns yellowish on weathering. Porphyritically interspersed through the rock are clear, almost transparent, rhomboidal crystals, from one eighth to one fourth of an inch long; these have been examined by Miss Hattie A. Walker and proved to be orthoclase."

The next notice of this rock is in the Proceedings of the Boston Society of Natural History (Vol. XXI. Part 3, p. 288), "On the Trachyte of Marblehead Neck," by Dr. M. E. Wadsworth, in which he says, "Near Boden's Point, on the northwest shore of Marblehead Neck, there is to be seen, exposed between high and low tide, the remains of a trachytic overflow." On page 290, Dr. Wadsworth says: "One of the feldspars, porphyritically enclosed in the groundmass, was obtained in the section. This is clear, glassy, and contains only a slight

amount of the groundmass and a few full fluid cavities. It is a simple crystal of sanidin."

Dr. Wadsworth's field-work upon this formation was very thorough, and but little is required in addition to his clear description of it. A few notes, however, taken from his description and the observations of the writer, may be of interest. This formation, now determined to be keratophyre, can be seen at low tide near the residence of Mrs. Harding on Boden's Point, Marblehead Neck. It appears as the much eroded remains of a surface flow, and extends two hundred yards in a northeasterly direction, with a width of sixty feet at the lowest point of observation. There are smaller masses of this rock three hundred yards from this point in the same strike (northeast), which are exposed only at extremely low tides. About five hundred yards south of Boden's Point, near Flying Point, the eruptive granite cuts the metamorphic slate of the Boston Basin series, and near this point also the granite is cut by dikes of quartz-porphyry (felsite). Near the keratophyre, and dipping under it, is a banded felsite. Both the granite and the felsite are cut by diabase dikes. The felsite tends to the northeast, and forms the larger portion of the bed rock of the Neck. The banding of this felsite dips towards the harbor nearly north, and lying upon it is the keratophyre. Between the lowest points of observation and the banded felsite, a conglomerate of varying thickness composed of fine felsitic débris, holding rounded and angular fragments of the felsite, is found in several places enclosed in the keratophyre. In some places the keratophyre rests directly upon the felsite, while in others the conglomerate intervenes between them. The line of contact between the keratophyre and the felsite débris is well marked; specimens of the keratophyre detached at this point show a basal surface very rough and pitted where it conforms to the irregularities of the conglomerate. The keratophyre, being exposed to the sun, rain, and the action of the frost and the ocean waves, is much decomposed on the surface; but the least altered specimens obtained are of a brownish or bluish gray color, having a conchoidal fracture and a compact groundmass, holding, occasionally, large glassy crystals of anorthoclase, some of which are one fourth of an inch in length, and, rarely, plates of biotite. The groundmass in thin section under the microscope is shown to be filled with lath-shaped feldspar crystals, which are somewhat decomposed. The base is an earthy kaolinized mass, with irregular masses of quartz and earthy limonite.

Dr. Wadsworth described the rock from microscopical study as consisting of a groundmass composed of ledge-formed crystals of feldspar,

either in single crystals or simple twins, which had the optical properties of orthoclase (although some might be triclinic) and enclosed between them varying amounts of a decomposed base, and of quartz which he regarded as secondary. The porphyritic crystals were determined as orthoclase (sanidin). The rock varied considerably in freshness in the several specimens. This rock, occurring thus as a surface flow, was called "Trachyte" under the classification used by Dr. Wadsworth, corresponding in this case to the "Quartzless Porphyry" of Rosenbusch.

During the season of 1889–90 eight sections of the keratophyre and several sections of the detached anorthoclase crystals have been prepared for microscopic study. Numerous crystals from the groundmass have also been detached for the purpose of obtaining the specific gravity and chemical analysis. Biotite mica is often found in hand specimens, and occasionally augite, although the latter has not as yet been detected in any of the sections cut.

In the light of our present knowledge and with further investigation it is possible to supplement Dr. Wadsworth's accurate descriptions, and to determine the feldspar phenocrysts as *anorthoclase*, and the rock as a *keratophyre*. The phenocrysts occur as crystals elongated parallel to $\breve{a}$, with a square cross-section owing to the presence of the base and brachypinacoid; in addition to the two cleavages there is a rough transverse fissuring. The crystals are quite glassy when fresh. In the rock slides, in polarized light, the different feldspar sections show marked optical peculiarities; there is often a very fine single, or double (microcline) twinning; sometimes the whole of one section of the mineral consists of irregular areas not extinguishing in common, which resemble the phenomena produced by mechanical causes; these areas contain very fine lines crossing each other at various angles in the different areas; in other cases there is a very fine zonal structure. Sections prepared parallel to the base show this fine irregular double twinning, and give an extinction 1° to 2° oblique to the line of the second cleavage (∞ P $\breve{\infty}$), and sections parallel to the latter cleavage give an extinction about 9° oblique to the line of the first cleavage, with an obtuse positive bisectrix about perpendicular to the face, the acute bisectrix a making the angle of 9° with the basal cleavage. These sections also show sometimes a very fine indistinct microperthite striation. The angle between the two cleavages was determined in the reflecting goniometer as approximately 89° 42′, about that of microline. The specific

gravity of fragments, determined by Westphal balance and Thoulet solution, was between 2.570 and 2.572.

The following analyses of the feldspar (I.) and the rock (II.) were made in the laboratory of the U. S. Geological Survey at Washington by Dr. Thomas Chatard.

	I. Feldspar.	II. Keratophyre.
H_2O at 110° C.	.04	.91
H_2O at red heat	.37	1.28
SiO_2	65.66	70.23
TiO_2*		.03 ?
P_2O_5		.06
Al_2O_3	20.05	15.00
Fe_2O_3	traces	1.99
FeO	traces	
MnO	.13	.24
CaO	.67	.33
MgO	18	.38
K_2O	6.98	4.99
Na_2O	6.56	4.98

	III. Gmelin, No. 1.	IV. No. 2.
SiO_2	65.90	65.19
Al_2O_3	19.46	19.99
Fe_2O_3	.44	.63
CaO	.28	.48
MgO		
K_2O	6.55	7.03
Na_2O	6.14	7.08
H_2O	.12	.34

Specific gravity 2.587.

It is evident from the analysis and optical properties that this is a triclinic soda-potash feldspar of remarkable purity, and very evenly balanced percentages of Na and K, belonging to the anorthoclase group of Rosenbusch. For comparison, analyses (III. and IV.) by Gmelin are appended of anorthoclase from the augite syenite of Norway (Brog-

* The TiO_2 was not very pure, and its presence is not absolutely certain.

ger, "Die Sil. Etagen 2 und 3," etc., p. 261). In the rock as a whole the same even balance between Na and K is noticeable, and the insignificant quantity of lime and magnesia. Allowing for the free quartz, base, and decomposition products as causing a relative increase of silica and iron and decrease of the alumina and alkalies, it is evident that the feldspars of the groundmass are closely allied chemically to the porphyritic crystals, and are probably also anorthoclase. The rock is therefore a very pure type of keratophyre.

The microscopical structure of the sections made are as follows : —

No. 21. Keratophyre with anorthoclase crystal cut obliquely to an optic axis. Groundmass made up of minute twinned lath-shaped crystals of feldspar, somewhat kaolinized, some quartz, and an earthy fibrous kaolinized base. In the centre of the porphyritic feldspar crystal are numerous microliths and a few ferritic masses, similar to and probably composed of the base, which penetrates the edges of the crystal.

No. 21 A. Keratophyre and an aggregate of the porphyritic crystals. Groundmass nearly as in No. 21. One of the phenocrysts shows twinning after the Carlsbad type.

No. 21 B. Keratophyre with one porphyritically enclosed crystal. The crystal is cut nearly parallel to the second cleavage, and gives an almost perfect interference figure of the positive bisectrix. The basal cleavage is well developed, and the striæ, or fine twinning, are well marked in polarized light The groundmass is more generally composed of the minute lath-shaped feldspar crystals, some of which are clearly twinned anorthoclase of the same form as the larger crystals. There are also small patches of quartz.

No. 21 C. Keratophyre with one large porphyritic feldspar crystal cut obliquely to the brachydiagonal, which in polarized light shows a microperthitic intergrowth and a very perfect example of fine and interrupted twinning. Through the crystal are several fluid cavities and a few microliths of a reddish color. The groundmass is more kaolinized, and the minute lath-shaped crystals are less distinct. Small irregular masses of quartz and considerable limonite and earthy matter pervade this section.

No. 21 D. Keratophyre section cut across a joint plane which is filled with vein quartz ; numerous irregular patches of quartz are scattered all through the section. One mass is a basal section of original (?) quartz ; it gives the uniaxial cross, and is shown to be positive by the mica plate. Some scales of biotite and numerous small grains of magnetite are seen in the groundmass, which is composed of a fibrous feebly polarizing kaolinized mass of the decomposed minute lath-shaped feldspar crystals. One of the enclosed phenocrysts cut nearly parallel to the base shows numerous microlithic inclusions, and several fluid cavities in which the bubble movement is seen The outer edge is deeply penetrated by the groundmass

The occurrence of this keratophyre as a surface flow in close proximity to the large intrusive masses of elæolite- sodalite- zircon-syenite of Salem Neck and the islands in Salem Harbor, and the augite- zircon-syenite of Marblehead and the Beverly shore, is interesting, as showing the various forms assumed here by the alkaline magmas under different geological conditions or at different periods.

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